An Industrial Controls Course Sequence for Manufacturing Engineering Technology

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Abstract

When the Society of Manufacturing Engineers (SME) published the results of its Profile 21 study, "Countdown to the Future: The Manufacturing Engineer in the 21st Century" in the Fall of 1988, a great push for examination and review of the curriculum content of academic programs in manufacturing and related areas began. In 1997 SME published its "Manufacturing Education Plan: Phase I Report," in which industry identified competency gaps that exist between current educational programs and the needs of industry. One specific competency gap which was highlighted in the Phase I Report was a gap in knowledge of industrial controls. To address this specific competency gap, a two-course sequence in industrial control systems has been added to the Manufacturing Engineering Technology program at The University of Memphis.

Introduction

In order to operate a healthy business that serves the needs of its customers, it is necessary to periodically examine customer needs and adjust the final product accordingly. This is also true with higher education. If asked the question, "Who are the customers of an academic degree program?" many in academia would argue that the students enrolled in the degree programs are the customers. There is no doubt that this is true, but it is a view from a single perspective. Perhaps at times the content and development of academic degree programs should be evaluated from a different perspective. This paper offers the alternate perspective that the companies that hire graduates of the program are the customers, and the graduates of the degree program themselves are the final product of the organization. Although this paper only examines one specific curriculum change in the Manufacturing Engineering Technology concentration at The University of Memphis, the information presented here illustrates the need for continuous improvement in all engineering and engineering technology programs.

Measuring Customer Satisfaction

In order to insure that products of the Department of Engineering Technology at the University of Memphis measure up to customer expectations, the degree programs are periodically reviewed. One means of review is through Industrial Advisory Committees, periodically reviewing program content and making suggestions for curriculum changes that may be needed to meet the more immediate needs of industry. These committees are comprised of middle- and upper-management representatives from area businesses who hire graduates of the programs. In some cases, the committee members themselves are graduates of the programs.

Another tool that is used is the periodic alumni and employer survey. These surveys are performed to evaluate quality and fitness of the graduates being produced. These surveys ask both the alumnus and the employer of the alumnus to rate technical skills and abilities in a number of areas, and to indicate those areas in which improvement is needed. Respondents are also asked to indicate areas in which they feel less emphasis is needed.

The Case for Change

In general, the information provided by respondents to the alumni/employer surveys is useful and valuable. In examining the data, however, a gap is seen to exist between what the alumnus perceives as areas in which improvement is needed and those areas in which the employer indicates a need for improvement.

This doesn't just happen with academic surveys, either. In a survey conducted by the National Association of Manufacturers (NAM) Center for Workforce Success and management consultants Grant Thornton LLP, a similar disparity was shown [1]. The survey asked practicing engineers to rate themselves, and also asked managers to rate their engineers by indicating those areas in which improvement would be necessary in order to attain long term goals. The results of this study are summarized in Figure 1:

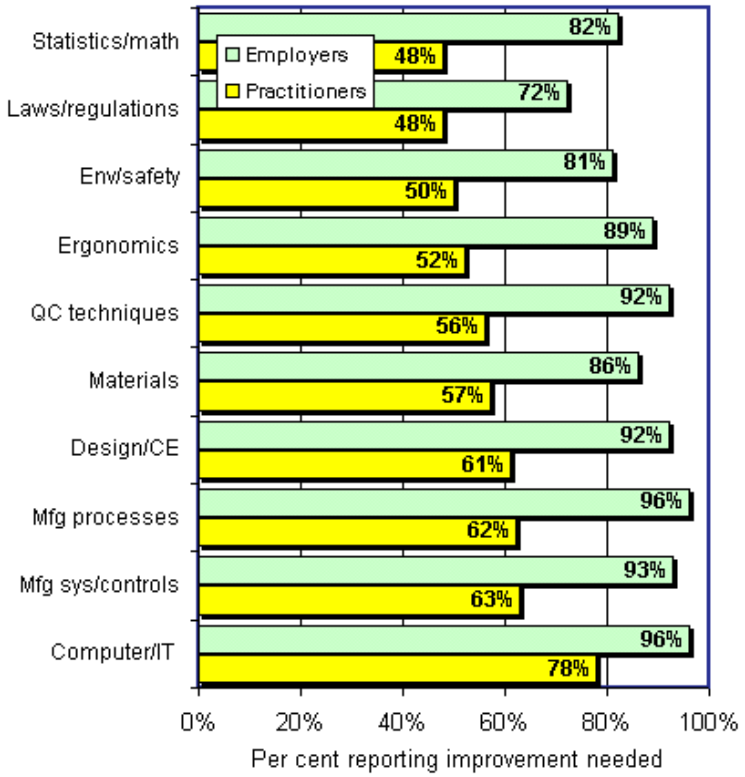

Figure 1: Gaps in Technical Skills [2]

The NAM study cited also found that 88% of the manufacturers surveyed are having a hard time filling at least one type of job, and that 43% can't find the engineers that they need. The problem is not a lack of applicants – it is a lack of technical skills in the applicants that they do get. And as can be seen from the results illustrated above, the skills gap isn't just with applicants, it exists with current employees, too.

These skills gaps are not a newly discovered problem. When the Society of Manufacturing Engineers published the results of its *Profile 21* study, "Countdown to the Future: The Manufacturing Engineer in the 21st Century" in the Fall of 1988, it indicated that the role of the manufacturing professional would have to change in order to meet the needs of a changing world.

The study outlined three distinct roles that the manufacturing engineer would be expected to play by the year 2000: the Manufacturing Strategist, the Technical Specialist, and the Operations Integrator. The Technical Specialist would require more depth skills, those normally taught in traditional engineering and technical disciplines. The Manufacturing Strategist would need more breadth skills, including a variety of nontechnical skills related to the overall business environment. The Operations Integrator would require a balance of both the depth and breadth skills, giving them the ability to participate across the enterprise and function as coordinators throughout the organization. Many of the graduates of the Manufacturing Engineering Technology program at The University of Memphis fall into the role of Operations Integrator.

With the release of the *Profile 21* study, it became apparent that changes would have to be made to the Manufacturing Engineering Technology (MET) program at The University of Memphis in order to produce graduates who could fulfill this role, but the exact requirements were not yet known.

Input from the Industrial Advisory Committee began to outline a number of changes that could be made to the MET program. Some of these suggestions indicated that some courses be removed from the program, and other courses revised to include new or expanded content.

Closing One of the Skills Gaps

One particular item that came up repeatedly was a need for MET graduates to have a working knowledge of industrial control systems. Students in the program take courses in dynamics, mechanical design and fluid power so that they have a general knowledge of machinery and machinery components. Some graduates even work as machine designers. Other graduates take positions in such areas as plant engineering, facilities planning and design, and distribution management – all areas in which an understanding of automation systems and industrial controls is beneficial if not a necessity.

In recent years, the design of physical systems and the design of the associated control systems have become so interrelated that a new term has been developed for it – *Mechatronics*. (A number of textbooks have been produced on the topic, and some schools even have degree offerings in the area). If the mechanical design and control systems design are properly integrated, the overall design and production cycle can be made shorter and more cost effective, and reliability can also be increased [3].

The need in these areas has been illustrated time and time again. In 1997 SME published its "Manufacturing Education Plan: Phase I Report," in which industry identified competency gaps that exist between current educational programs and the needs of industry. Terminology that comes up repeatedly when describing these competency gaps includes the physical control of machinery, open and closed loop systems, and sensors [4].

Beginning in 1997, the Manufacturing Engineering Technology (MET) program at The University of Memphis began requiring a 2-course sequence in Industrial Controls. Although two years in the works before the first successful offering of the course sequence, SME's Phase 1 Report confirmed what the Industrial Advisory Committee had been saying.

It's Different

This two-course sequence is designed specifically for the Manufacturing Engineering Technology major. The courses were developed by faculty in the Electronics Engineering Technology (EET) program, and are taught by EET faculty. The content of the courses was developed based on the practical industrial experiences of the EET faculty.

MET majors begin by taking an introductory DC/AC circuits course at the freshman level, right alongside EET majors. That is where the similarity ends. An EET major will then take two courses in solid-state electronics, and will then complete a four-course sequence in industrial electronics and control systems.

The first course in the MET sequence is made up of selected topics from four of the courses that an EET major would take (see Figure 2). It is intended to provide an overview of solid-state electronics and devices, particularly as applicable to industrial control systems. Diodes (power supply and switching circuits), transistors (switching circuits and small signal amplifiers), thyristors (SCRs, Triacs, and triggering circuits), and operational amplifiers (integrators, differentiators, summing and difference amps and other applications) and their specific uses in industrial control are examined. Students are introduced to the fundamentals of digital logic and how it translates to hardwired relay logic control. The course also provides an overview of the sensors and transducers commonly used in industrial control as well as common output devices such as AC and DC motors, motor starters, and various types of solenoids.

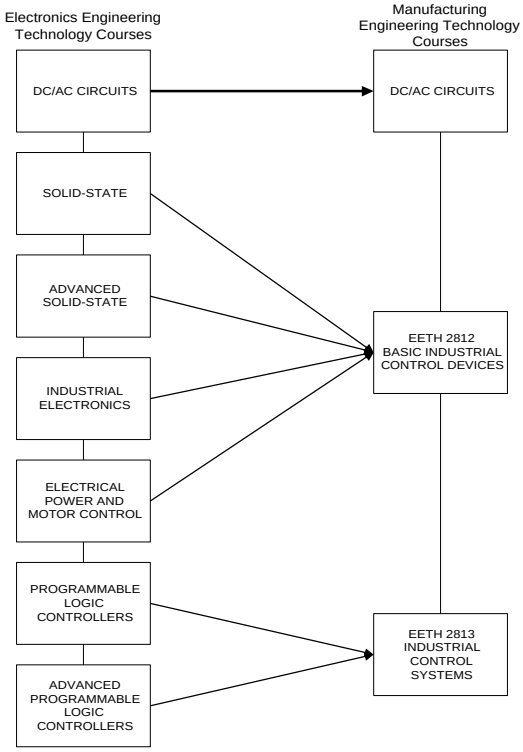

Figure 2: Comparison of EET and MET Course Requirements

The second course in this sequence emphasizes the use and applications of Programmable Logic Controllers. This course begins by examining the hardware, addressing, and basic instruction set in enough detail so that the student may begin writing PLC programs for laboratory exercises. The course continues examining the

instruction set; however, not in as much detail as it is covered with EET majors. The course also introduces the student to analog I/O modules, Remote I/O, and Data Highway Plus communications as would commonly be seen in machine and/or process control applications. Students perform laboratory exercises to solve a variety of control scenarios, in which they write and troubleshoot ladder logic programs. The use and application of photoelectric and proximity sensors is also covered in detail in this course.

It is important to note that many of the topics in these two courses are covered from more of a "capabilities and limitations" perspective. The goal is to provide the Manufacturing Engineering Technology graduate with a level of competency in these areas so that they are able to discuss and evaluate different control strategies that they may be involved with. They should also be more comfortable troubleshooting automated control systems as a result of this experience. They will also have the basis for further self-study and professional development in these areas, should they need to do so.

Conclusions

Feedback from students who have completed the sequence has been favorable. A number of both current students and graduates of the program are employed in positions having titles and responsibilities such as "Plant Engineer," "Project Engineer," or "Project Manager," the specific duties of which are closely related to the **Profile 21** description of an Operations Integrator. Most of these individuals are involved with the design, specification, installation and prove-out of new equipment and technologies in their facilities, or are responsible for upgrading and automating existing processes and procedures. The knowledge gained through completion of this sequence of courses has allowed them to perform their job functions more effectively.

Preliminary feedback came at the end of the first offering of the two-course sequence, when students were asked to write a short critique of the courses. They were urged to offer comments, criticisms and suggestions for improvement of the courses. Most of the students were pleased with what they had learned, and some indicated that they had already been able to use the knowledge gained in their jobs. "I can't believe we didn't have these courses a long time ago," said one of the students. Another indicated that what he had learned helped him to get a promotion which made him responsible for managing a project in which a new automated material handling system was being installed.

Right now these courses are addressing one specific competency gap, with content being based on what is now state-of-the-art. But what is now state-of-the-art may be obsolete in the near future, and course content must be constantly monitored and updated. Many other competency gaps exist, but as this paper illustrates, they can be closed.

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The author earned a BSET Degree with a concentration in Computer Systems Technology from Memphis State University in 1987 and an MS Degree with a Manufacturing Engineering Technology concentration in 1991, also from Memphis State University. His industrial experience covers a broad range of functions involving industrial automation, machinery design, facilities planning and material handling systems design. He served as an adjunct faculty member for three years before joining the faculty full-time in the Fall of 1994, and is now Assistant Professor and Program Coordinator for the Electronics Engineering Technology program at The University of Memphis.